Blood Storage for Transfusion

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This is a preliminary report describing the storage of blood for transfusion, and comparing the results obtained in the first fifty cases transfused with those of fresh blood transfusions.

Blood storage is a definite advance in blood transfusion therapy, the use of such blood having a number of advantages over fresh blood; notably the saving of time, and the fact that the blood may be collected to suit the mutual convenience of the donor and of the doctor responsible for the venesection. Thus its advantage in an emergency, and in war time when many urgent transfusions may be necessary, would be very great. It is also a means of avoiding the waste of blood, as the blood collected from cases where venesection is done as a therapeutic measure need no longer be thrown away, but may be kept until a suitable occasion arises for its use. In addition to the healthy donor and the therapeutic venesection, the source of the blood may be from the placenta or the cadaver. Cadaver blood differs from that from other sources in that it is said not to require the addition of anticoagulant preserving solution. The method has been employed to a considerable extent in Russia, and is still on trial.

Most of the blood which I have stored was obtained from therapeutic venesections, and included cases of hypertension, cardiac failure, and polycythæmia. Albuminuria or an increase in the blood urea do not constitute a bar to the use of the blood, and such blood has been used with similar results to the blood from normal donors. Some of the bloods were from healthy subjects, and a few were placental.

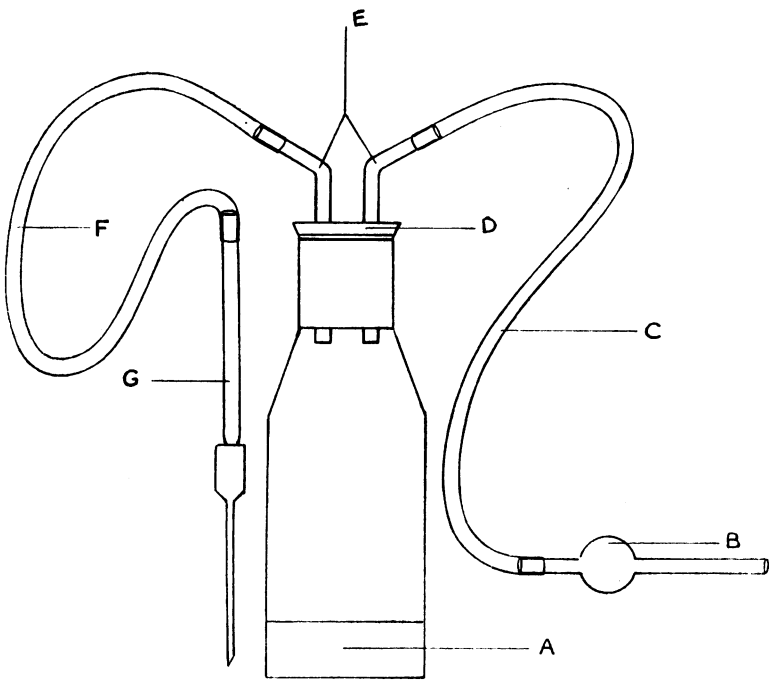
The number of anticoagulant preserving solutions used is large, but after trying many different solutions I have found the following, composed by mixing one part Solution 1 with three parts Solution 2, before use, to give the best results:

Solution 1	Sodium Citrate	3.8 g.
	Bi-distilled Water	100 c.c.
Solution 2	Glucose	5.0 g.
	Bi-distilled Water	100 c.c.

Further trials may require a slight modification of this solution. Experience has shown that adherence to the proportions in which the two solutions are mixed is very important if the best results are to be obtained. The total amount of the preservative used is also important, the blood keeping best when the quantity is large. A fixed quantity of 200 c.c. has been found to be a suitable amount to use, volumes of blood up to 500 c.c. when mixed with this volume of preserving solution keeping in a state suitable for transfusion for many weeks. The method of preparing the solutions is important. 150 c.c. of the glucose solution are sterilized in the collection bottle in the steam sterilizer. Glucose cannot be satisfactorily autoclaved or sterilized with the sodium citrate, 50 c.c. of which are separately

sterilized in a small flask. After sterilization the containers are kept in the ice chest until required for use. While this solution has been found to be the one of choice for keeping blood in storage for long periods, 3.8 per cent. sodium citrate alone has been found quite satisfactory for the preservation of blood for short periods. One part of 3.8 per cent. sodium citrate when mixed with nine parts of blood will keep the mixture in a satisfactory state for transfusion for from one to two weeks.

The method of venesection is similar to that ordinarily used, and the time at which it is done does not appear to be of any significance, though the cases done on a fasting stomach tend to give a clearer supernatant plasma than those done directly following a meal. This, however, did not appear to influence the quality of the blood, its keeping properties, or its sterility. The blood cultures were invariably sterile. The chief factor in the venesection is that the blood should run off easily without any impediment. If any difficulty is experienced in getting off the blood it is unlikely to keep well. Trauma at all stages is to be avoided. The blood collection bottle consists of an ordinary one-pint or two-pint milk bottle (see diagram), according to the amount of blood for collection. This is stoppered with a rubber bung D,



Apparatus for the collection of blood.
(For details see text)

containing two holes. Short pieces of glass tubing E are passed through these holes, a moderate bend being present on the outside portion. The glass tubing is stoppered with cotton wool, and the whole assemblage containing the glucose solu-

tion A, is kept ready sterilized in the ice chest. When required for use the cotton-wool plugs are removed from the glass tubes which are flamed to ensure sterility. To one of them is then attached a piece of rubber tubing F, approximately one foot long. At the free end of this tubing the venesection needle is inserted. This consists of a small needle made of nickel steel, size 14/10, and not exceeding one and a quarter inches in length. Into the hub of the needle is inserted a piece of glass tubing G, approximately three inches long, which may be kept in place with plaster of paris. This glass tubing serves as a handle for the insertion of the needle and also as a sight, blood showing in it immediately following entry of the needle into the vein. To the other piece of glass tubing is attached a rubber tube C, approximately two feet long; at its free end is inserted a glass tube B, about three inches long, and which contains a cotton-wool filter. Before use, the rubber tubes and needle are sterilized by boiling. The citrate solution is drawn into the bottle by applying buccal aspiration to the glass tube B. The resultant glucose-citrate mixture is well shaken, ensuring that all parts of the collection bottle are wet by it. The donor is prepared in the usual way lying down. A sphygmomanometer cuff is adjusted on the arm, and the region of the antecubital fossa is prepared. A pressure of 80 mm. Hg. is maintained by the sphygmomanometer and the needle is inserted in an appropriate vein, no local anæsthetic being required owing to its small size and sharpness. The needle is sharpened before each venesection. In most cases the blood will flow quite freely, intermittent clenching of the donors hand being a help. If the blood does not flow freely this can be brought about by applying slight buccal aspiration. Following collection the blood is stored in the ice chest at a temperature of 4°C., the rubber tubes being removed and replaced by sterile rubber caps. Rubber teats serve very well for this purpose. The blood is tested for its sterility, Wassermann reaction, and type.

On standing, the blood mixture separates into layers which appear in a definite order. Two easily distinguished layers first appear consisting of a lower one of the red blood cells, and an upper one of the plasma. In addition to these two primary layers, a third very thin layer containing the leucocytes appears within a few days at the junction of the other two layers. Should the plasma layer originally be cloudy, this may clear from above downwards. After standing for a varying length of time, but usually subsequent to the third or fourth week, a fourth layer appears as a buff ring directly above the intermediate third layer. This consists of red blood cells which have floated up into the plasma layer, and it finally assumes the clear red colour associated with hæmolysis of red blood cells. This final hæmolysis does not appear for some weeks following the appearance of the fourth layer, and it has been found that no ill effects follow the use of the blood prior to the onset of this hæmolysis. No blood has yet been used subsequent to this stage. The time of appearance of these later stages depends on many different factors, such as the nature of the preserving fluid, and its volume to that of the blood. Also important are the efficiency of the venesection and individual blood variations. Present indications are that the times given here may be extended with further experience.

Prior to use, the blood is heated in a water bath at a temperature of approximately 40°C. for about fifteen to twenty minutes. It does not appear to be essential that the blood should be brought to blood heat, and for a drip transfusion it is not necessary to heat it at all. Also for a transfusion which is given very slowly with blood which has been permitted to stand long enough at room temperature to lose its chill, heating does not appear to matter; but ordinarily where the blood is given soon after removal from the ice chest, I prefer to stand it in warm water as indicated above, while the necessary preparations for the transfusion are being made. The blood is gently mixed and filtered through sterile gauze. Some form of filtering is essential, as even though no clots are present a good deal of fibrinous material may have formed. The actual method of administration does not differ from that of fresh blood. I prefer to give it at the rate of fifteen to twenty cubic centimetres a minute. The actual preparations do not take long, and the blood may be in process of administration to the patient in as short a time as fifteen minutes. In addition to typing the preserved blood and that of the patient, a direct match is also done; the patient's serum being mixed with the preserved red blood cells.

The first fifty cases which were transfused with preserved blood comprised:

Twenty-seven transfusions for shock and hæmorrhage. The majority of these were post-operative cases, and cases of hæmatemesis. The oldest blood used in this group was thirty-five days.

Seven transfusions for symptomatic anæmia, the preservation time of the oldest blood in this group being ten days. Included here were cases of uterine bleeding, melæna, carcinoma of the cervix, and ulcerative colitis.

Five transfusions for leukæmia in which the preservation time of the blood ranged from two to twenty-eight days.

Three transfusions for hæmophilia with blood preserved for fourteen days, seventeen days, and twenty-three days.

Three transfusions for aplastic anæmia in which the blood had been stored for one day, seven days, and twenty-three days.

Two transfusions for microcytic anæmia with bloods preserved for three days and seventeen days.

Two transfusions for pernicious anæmia, one in which the blood had been preserved for six days, and in the other for eight days.

One transfusion as a pre-operative measure, with a mixture of two bloods which had been stored for five days and ten days.

Comparing the results obtained from these transfusions with those of fresh blood transfusions no essential differences were noted. They appeared to be quite as beneficial, the cases of shock and hæmorrhage responding well to them, and the oozing of blood which occurred following certain operations such as those to the gall-bladder was checked. All the seven cases of symptomatic anæmia derived benefit from their transfusions, and one case of ulcerative colitis in particular, who

had had several transfusions previously with fresh blood, responded to the preserved blood with a very good result. The five cases of leukæmia all derived temporary benefit from their transfusions. In the cases of hæmophilia the transfusion had the same effect in controlling the bleeding as had fresh blood, and the clotting time was also lowered. The three cases of aplastic anæmia derived a temporary benefit from their transfusions. The two cases of microcytic anæmia responded well. In the two cases of pernicious anæmia one did well; while the other, an aged patient in relapse, derived transient benefit. The result in the pre-operative transfusion was good. No ill effects resulted from any of the transfusions, and no rigors occurred. The only reaction encountered was in a hæmophiliac, who developed a mild transient urticaria following the administration of blood which had been stored for twenty-three days. The same patient had, however, had a similar reaction previously following the administration of fresh blood. The transfusion itself was beneficial.

With the exception of one transfusion which was done with placental blood, all of these were done with the blood obtained by venesection. The placental blood was given to a case of leukæmia with temporary benefit, and it is probable that placental blood is quite as satisfactory for transfusions as fresh blood, but it would be uneconomic to use it in most circumstances. The reason for this is that the yield from each placenta is not very great, about 60-80 c.c., and so the blood from more than one case will have to be used for an average transfusion. Also I think it is essential that the blood should be collected by a doctor with the proper experience, and again it should be looked after by a bacteriologist. A great deal of skilled work is therefore entailed with one placental blood, to which has also to be added the preparation of the apparatus and solutions. And as all this requires to be multiplied several times for each transfusion, the method is unsatisfactory where economic factors are taken into account. Regarding the preparation of the apparatus, I consider it as very important in all blood transfusion work that it should be very thoroughly cleaned, ensuring that it is entirely free of blood from any previous transfusions. All the apparatus has been prepared by first washing in tap water, then boiling in a weak alkaline solution; the rubber tubes in weak sodium bicarbonate, and the rest of the apparatus in weak caustic soda. After this it is again thoroughly washed in tap water, and finally with distilled water. Special attention must be paid to the cleaning of the rubber tube used for the venesection, and the mere pouring of water through it is not sufficient to wash out the blood. To ensure proper freeing of the tube of old blood it requires very thorough kneading and the forcing of water through it at high pressure. Attention to these details, and the proper administration of the blood will almost entirely eliminate blood transfusion reactions.

While no essential differences have been noted between fresh blood and preserved blood for transfusions, it is unlikely that the effect of the two is entirely similar. The impression gained is that preserved blood is slightly superior. Its immediate effects would appear to be much the same as those of fresh blood, but

it appears to have a greater stimulating effect on the hæmopœitic system, so that the final effect is rather better. Fresh blood may, however, be superior for cases of infection owing to its higher titre of complement.

SUMMARY.

The advantages of blood storage are stressed. Its greatest advantage is the saving of time, which may be a very important factor in an urgent case.

A satisfactory method of blood preservation is described. While the preservation time of the oldest blood so far administered was thirty-five days, present indications are that this time may be considerably extended. It requires emphasis, as previously stated, that the period during which preserved blood remains in a state suitable for transfusion is not a constant one, but varies with the method of preservation. With many of the methods in use this period is limited to about two weeks; but this time may be considerably extended by the method given here.

The results in the first fifty cases transfused with preserved blood are compared with fresh blood transfusions. No essential differences were noted.

Quacks, Astrologists, and Medicine

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FROM the earliest times all manner of strange substances were used in the treatment of disease, particularly in the seventeenth and the eighteenth centuries. One of the most highly esteemed of these was the so-called bezoar stone, which was said to be found only in the "belly of she-goats." This substance was used in many ways, both internally and externally, and was greatly favoured for curing "the most obstinate Cutaneous Diseases by external application of the Powder to Leprosies, Erisypelas and Pestilential Sores." Its great objection appears to have been the price, for Dr. Slare in 1715 complained that it cost "Three Pound and Ten Shillings per pound weight, and the finest quality no less than Four Pound."

Minced hair was a favourite "drug" at this time for the treatment of worms. This drug was classed as a "dangerous drug," and Dr. Tancrad, in 1715, "a Learned Virtuoso and Experienced Physician," described a case in which death occurred. He wrote: "He was sent for to see a Young Woman, whom he found in such dismal and terrible Convulsions, with such terrible Contorsions of her Body, that made him nicely enquire into the cause of such frightful Symptoms; which he rationally concluded to proceed from a large Quantity of Minced Hair her Mother had given her for several Days together, before the Convulsions attacked her, with the Design to kill the Worms she had been afflicted with."

In country districts in parts of England, it is said even to this day, that a ring made from a piece of silver collected at the communion in church, or from small coins given by five bachelor friends, unknowingly to one another, and worn constantly on one of the patient's fingers, will protect against attacks of epilepsy.